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Field Modelling in the Highland Silver Lake Watershed

Illinois State Environmental Protection Agency
Springfield

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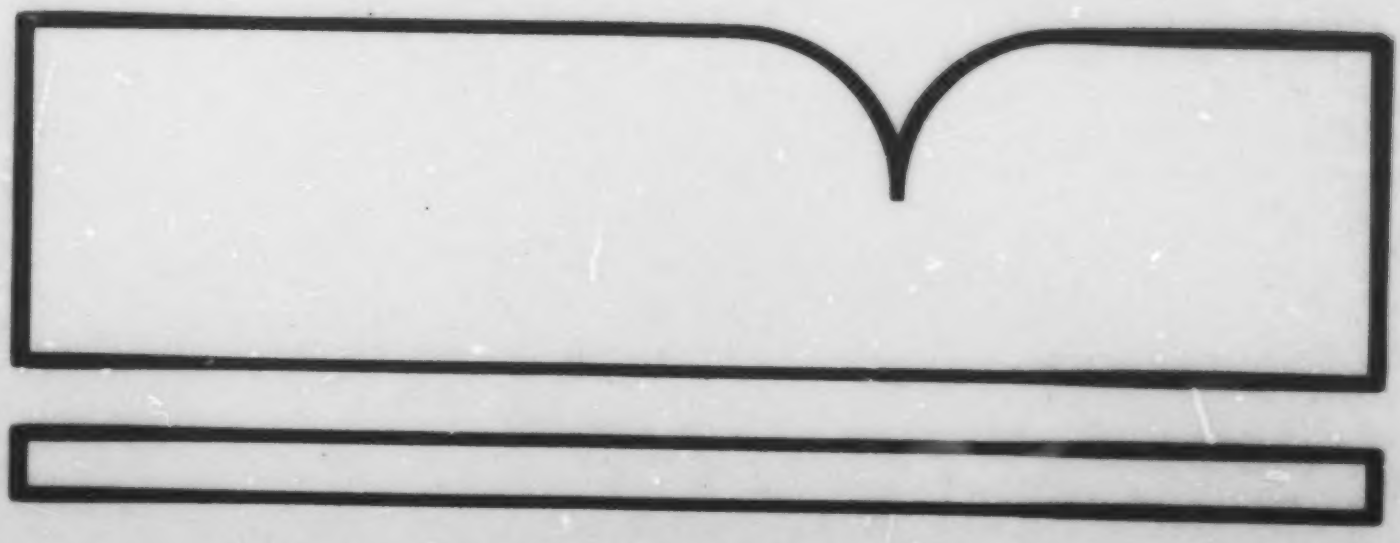

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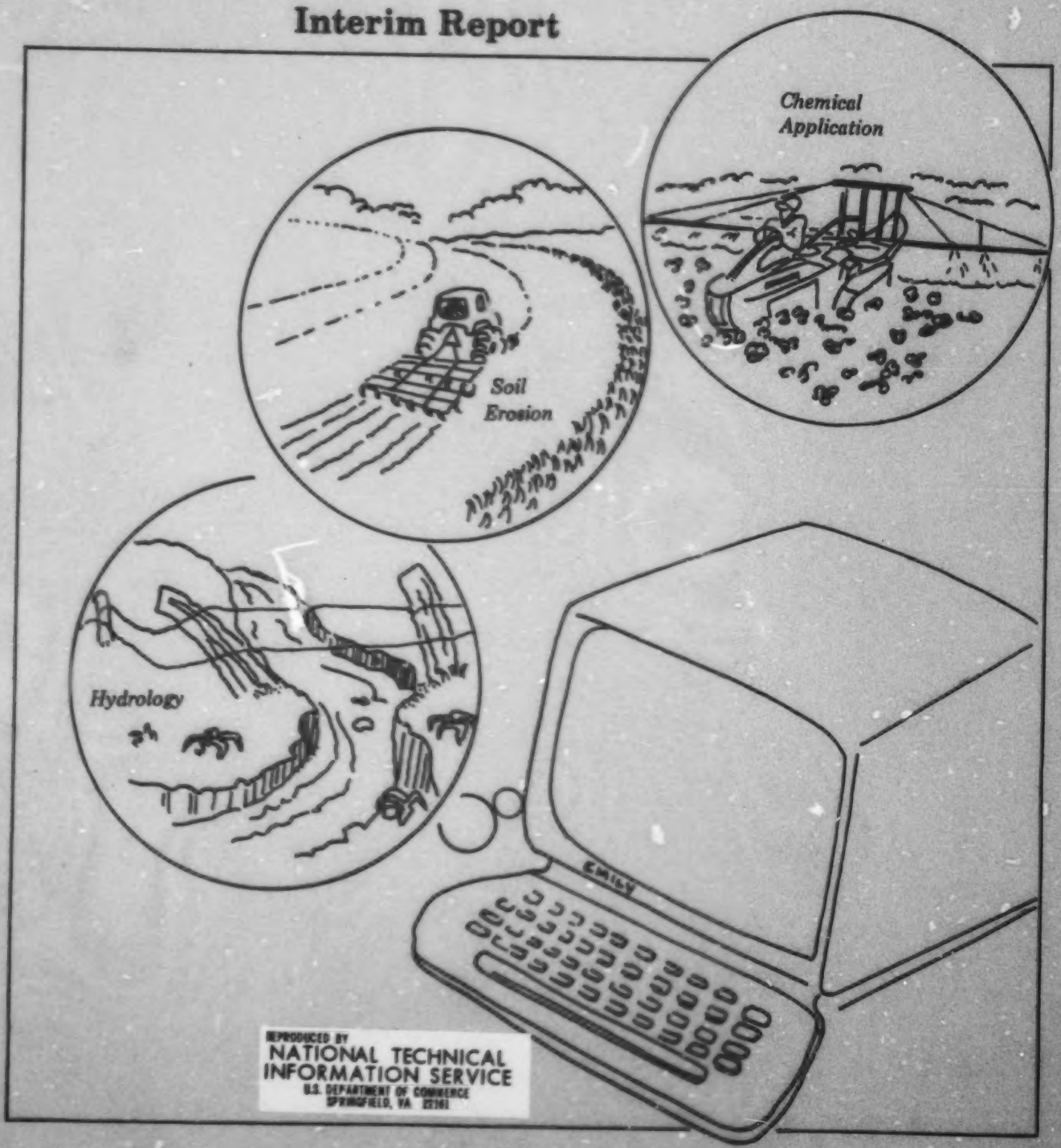
Interim Report



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This report is a product of the Comprehensive Monitoring and Evaluation Program for the Highland Silver Lake Watershed-Rural Clean Water Project. Adequate control of agricultural non-point source pollution requires an effective and efficient management program. An integral component of this is the identification of those resource management systems which can control non-point source pollution at the source. CREAMS (Chemical, Runoff and Erosion from Agricultural Management Systems), a mathematical model, was utilized to estimate the effectiveness of various resource management systems on four field sites.

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Field Modelling in the Highland Silver Lake Watershed

Interim Report

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Abbreviations and Symbols

IEPA:	Illinois Environmental Protection Agency
USDA	United States Department of Agriculture
ASCS	Agricultural Stabilization and Conservation Services
SCS:	Soil Conservation Service
RMS's:	Resource Management Systems
ICES:	Illinois Cooperative Extension Service
ARS:	Agricultural Research Service
SIMPAC:	Southwestern Illinois Metropolitan and Regional Planning Commission
ERS:	Economic Research Service
ac:	Acres
ha:	Hectares
kg:	Kilograms
G:	Grams
cm	Centimeters
CREAMS:	Chemicals, Runoff, and Erosion from Agricultural Management Systems.
ER:	Enrichment ratio of sediment
SY:	Sediment Yield
bu/ac:	Bushels per acre
CM & E:	Comprehensive Monitoring and Evaluation

Preface

This report is a product of the Comprehensive Monitoring and Evaluation Program for the Highland Silver Lake Rural Clean Water Project. This project is one of five in the nation designed to evaluate the effectiveness of the U.S. Department of Agriculture (USDA) Rural Clean Water Program.

Funding for the Rural Clean Water Program and Comprehensive Monitoring and Evaluation Program is provided by the USDA Agricultural Stabilization and Conservation Service. The U.S. Environmental Protection Agency is assisting USDA in evaluating the effectiveness of the Rural Clean Water Program in improving water quality. The USDA, Soil Conservation Service, which provides technical assistance in the Rural Clean Water Program, is also responsible for oversight of the Comprehensive Monitoring and Evaluation Program. The University of Illinois Cooperative Extension Service provides education/information assistance in both programs.

Agencies participating in the Comprehensive Monitoring and Evaluation Project include: the Illinois Environmental Protection Agency, which is responsible for water quality monitoring and evaluation; the Illinois State Water Survey, responsible for water quantity monitoring and evaluation; the USDA Economic Research Service, responsible for the socio-economic evaluation of the project with assistance provided by the University of Illinois -- Department of Agricultural Economics, on the on-farm economic analysis; and the Southwestern Illinois Metropolitan and Regional Planning Commission, on the off-site economic analysis. The Commission is also responsible for coordination of the Comprehensive Monitoring and Evaluation Project. The University of Illinois Agricultural Experiment Station and the Illinois Department of Conservation are providing voluntary assistance on various aspects of the project.

The Illinois State Rural Clean Water Coordinating Committee is providing oversight for the Highland Silver Lake Watershed Rural Clean Water Project and assisting USDA and EPA in their comprehensive, joint water quality monitoring and evaluation, including coordination with the Local Coordinating Committee. Membership of the Illinois State Coordinating Committee consists of the following:

Illinois State ASCS Committee
Farmers Home Administration, USDA
Cooperative Extensive Service, USDA
U.S. Forest Service, USDA

Soil Conservation Service, USDA
U.S. Environmental Protection Agency -- Region V
Illinois Environmental Protection Agency
Illinois Department of Agriculture, Division of Natural Resources
Illinois Department of Conservation
Economic Research Service
Illinois Department of Energy and Natural Resources - State Water Survey

ACKNOWLEDGEMENTS

This project was financed in part with funds from the United States Department of Agriculture (USDA). The contents of this report do not necessarily reflect the views of the USDA. Mention of specific models and products does not constitute endorsement for use and does not imply approval of them to the exclusion of other products or models.

The guidance and assistance provided by the United States Department of Agriculture-Soil Conservation Service (SCS) under the direction of State Conservationist, John J. Eckes, is gratefully acknowledged. Specifically, Edward Johnston, Steve Black, Wayne Kinney, Steve Probst, John Lowrey, and Dana Walker of the SCS were very helpful. Lee Rogers, Nancy Wiemers, Audrey Renken (ASCS) provided assistance in this project. Duane Frederking (ICES) was invaluable to this effort due to the cooperator files he provided.

A special acknowledgement goes to Harvey Sundmacker and Lee Austin, SCS, for providing the CREAMS information utilized in this report. Drs. Tom Dumper (SCS) and George Foster (ARS) provided technical assistance for using the CREAMS 1 model.

John Little of the Illinois Environmental Protection Agency (IEPA) provided data analysis assistance for this project. The editorial comments of Dave Carvey, John Lowrey and Harvey Sundmacker were appreciated. The guidance and editorial comments of Dr. Thomas Dumper and Toby Frevert were greatly appreciated. This report was typed by Charla Bacon of the Word Processing II Unit under the direction of Norma Kraus and printed by the Print Shop under the direction of Claude Pearson. Gloria Ferguson created the cover and assisted with the graphics. Nancy Simpson and Susan Carlson assisted in the collection of the literature.

EXECUTIVE SUMMARY

1. Background: The Illinois Environmental Protection Agency (IEPA) in cooperation with various State and Federal agencies, is evaluating the impact of Resource Management Systems (RMS's) implemented under the Rural Clean Water Project in the Highland Silver Lake Watershed, Madison County, Illinois. The primary objective of this comprehensive monitoring and evaluation project is to document the effectiveness of land treatment program in terms of water quality/quantity impacts.

2. Investigation: Adequate control of agricultural non-point source pollution requires an effective and efficient management program. An integral component of this is the identification of those RMS's which can control non-point source pollution at the source. CREAMS (Chemical, Runoff and Erosion from Agricultural Management Systems) was utilized to estimate the effectiveness of various RMS's on the selected sites.

   CREAMS was used to model four sites within the Highland Silver Lake Watershed. The size of the sites ranges from 20 to 58 acres. All three components of the CREAMS model were utilized in these simulation. Present land management activities and potential recommended land management activities were simulated for each site. Comparisons were then made between the simulations to determine the impacts of the various proposed land management activities.

3. Discussion and Conclusion: Computer simulations indicated no-till operations are extremely effective in reducing sediment yield in comparison to conventional and reduced tillage. Due to the rainfall pattern utilized in this study; reduced tillage systems were not as effective as reported in the literature. Contouring, grassed waterway and grade stabilization structures were effective in reducing sediment yield in the various simulations.

INTRODUCTION

Agriculture is the most widespread non-point source of water pollution across the nation. Initial water quality management planning efforts documented that agricultural activities are a major source of pollution in Illinois and mandated the development of plans to control this non-point source pollution from agriculture. The Federal Water Pollution Control Act (P.L.: 92-500 as amended) was the impetus for selecting and prioritizing rural water quality projects within the State of Illinois. Highland Silver Lake was one of the priority lakes for agricultural non-point source water quality problem abatement (IEPA, 1979).

Due to the agricultural base of the watershed, the non-point source pollutants likely to be the greatest concern in Highland Silver Lake are suspended solids, nutrients and pesticides. These pollutants can impair the following intended uses of the water resources: drinking water supplies, fisheries and wildlife, recreation, industrial and agricultural. The primary pollutant within the watershed is suspended solids. (Davenport and Kelly, 1983) High nutrient levels in the lake are recognized as a potential problem given a reduction in suspended solids concentrations and increased visibility.

BACKGROUND (ISCC, 1983)

Public Law 96-108 authorized the Experimental Rural Clean Water Program (RCWP), which provides long-term financial and technical assistance to agricultural landowners and operators. The purpose of this assistance is to improve water quality through the installation and maintenance of resource management systems (RMS's) to control agricultural non-point source pollution.

"The objectives of the RCWP are to:

a) Achieve improved water quality in the approved project area in the most cost-effective manner possible in keeping with the provision of adequate supplies of food, fiber and a quality environment.

b) Assist agricultural land owners and operators to reduce agricultural nonpoint source water pollutants and to improve water quality in rural areas to meet water quality standards or goals.

c) Develop and test programs, policies and procedures for the control of agricultural nonpoint source pollution."

The Highland Silver Lake Watershed in Madison and Bond Counties, Illinois was selected as one of 21 experimental RCWP areas. Farmers in the watershed enter into contract with the U.S. Department of Agriculture, Agricultural Stabilization and Conservation Service (ASCS); the basis for this contract is a water quality plan prepared with technical assistance from the Soil Conservation Service. (SCS). The contract period is not less than three nor more than ten years, the eligibility period for contract signing is 5 years; hence, the life span of the existing RCWP projects is estimated at 10 to 15 years.

All RCWP's are required to monitor RMS implementation progress and water quality improvement trends through the life of the project. Five of the RCWP areas were funded for comprehensive monitoring and evaluation. The Highland Silver Lake Watershed RCWP was one of the five selected for the more intensive monitoring.

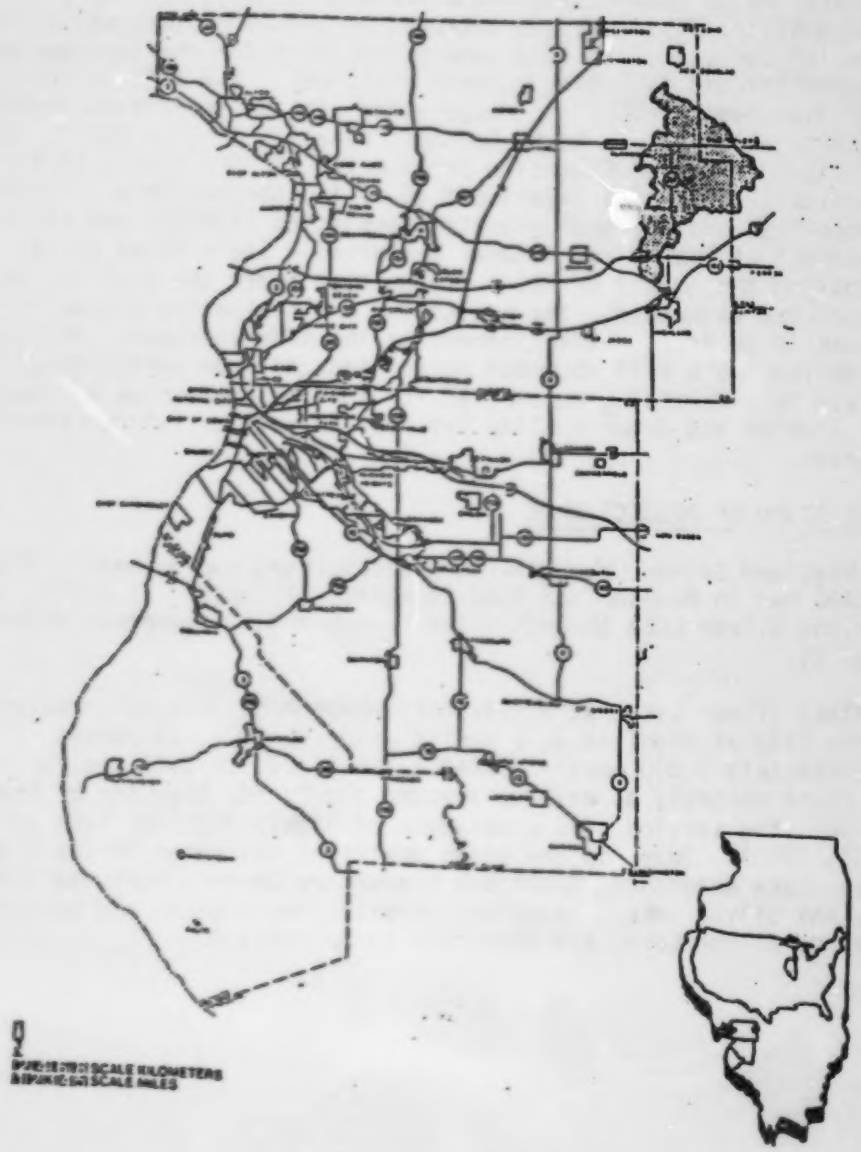


Figure 1: Regional Location of the Highland Silver Lake Watershed.

HIGHLAND SILVER WATERSHED PROJECT

The Highland Silver Lake Watershed in Madison County, Illinois (Fig. 1) was selected to demonstrate the effects of erosion control practices upon water quality. The area was selected as a RCWP project which provides financial assistance to land owners/operators for the implementation of conservation and pollution control practices. The Illinois Environmental Protection Agency (IEPA) in cooperation with United States Department of Agricultural Agencies; ASCS, Economic Research Service (ERS), SCS, Illinois Cooperative Extension Service (ICES), University of Illinois Agricultural Economics Department (U of I), Southwestern Illinois Metropolitan and Regional Planning Commission (SIMAPC) and Illinois Department of Energy and Natural Resources - State Water Survey (SWS), is evaluating the impact or RMS's implemented under the RCWP in the Highland Silver Lake Watershed. The monitoring and evaluation project's primary purpose is to assess effectiveness of the RCWP approach. Monitoring and evaluating RMS's will document actual impacts from agricultural practices and aid in determining strategies for the implementation of the State Soil Erosion and Water Quality Program, as well as future Federal programs.

DESCRIPTION OF PROJECT AREA

The Highland Silver Lake Watershed encompasses approximately 31,000 acres (12,400 ha) in Madison and Bond Counties, Illinois. It drains into Highland Silver Lake through Silver Creek and its numerous tributaries (Fig. 2).

Highland Silver Lake, an artificial impoundment, was constructed in 1961 by the City of Highland as a public water supply. It serves approximately 9,000 people (SIMAPC, 1983). It is utilized for recreation and flood control, as well as a water supply for the City of Highland. In 1980, the service area population of Highland Silver Lake was 8,759 (ISCC, 1983). There is one known municipal discharge in the Highland Silver Lake Watershed, Grantfork Elementary Center, upstream from Highland Silver Lake. Location, physical description and morphometry of Highland Silver Lake, are presented in Appendix A.

Figure 2

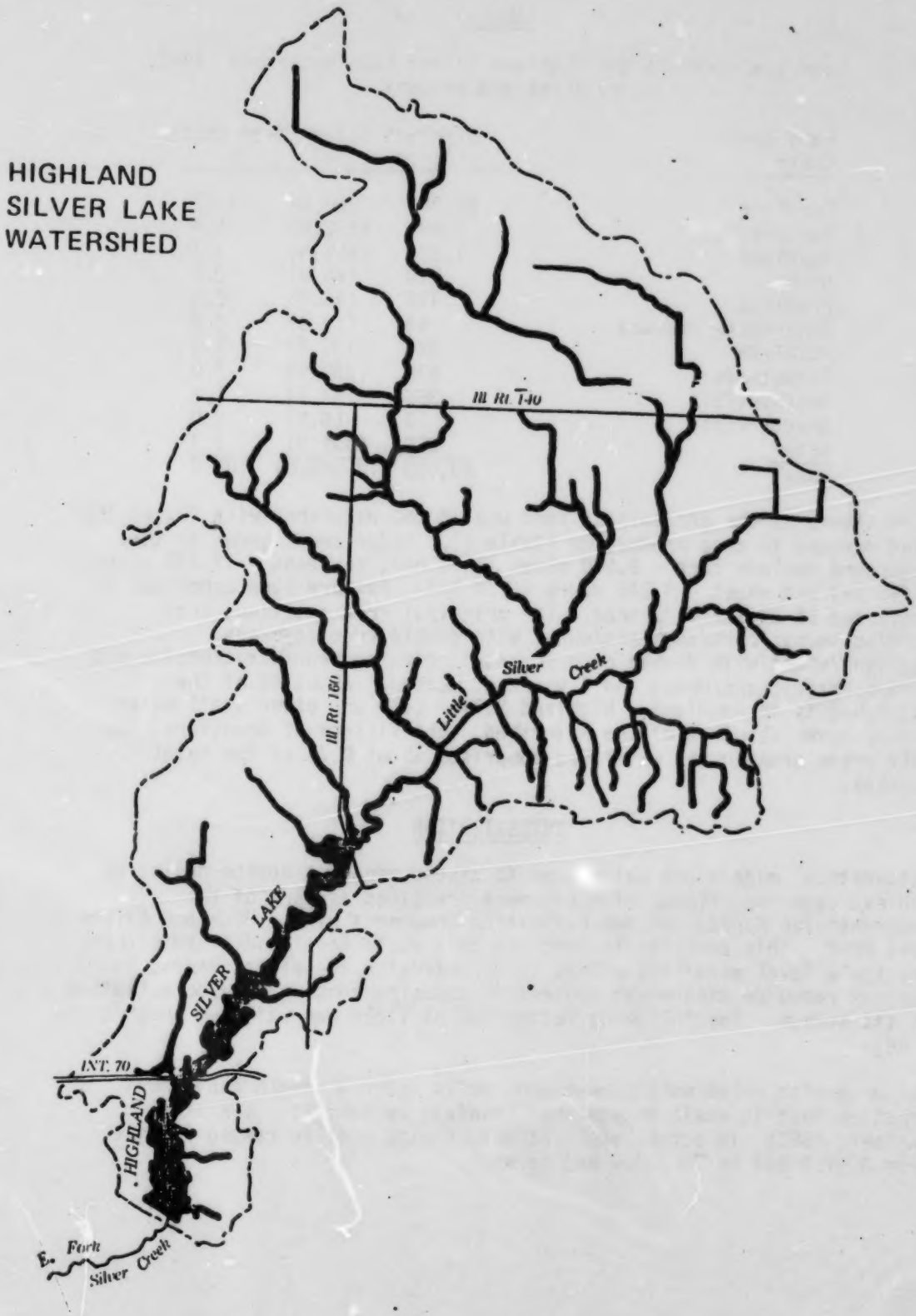

HIGHLAND
SILVER LAKE
WATERSHED
Ill Rt 140
Ill Rt 160
Little Silver Creek
LAKE
SILVER
INT. 70
HIGHLAND
E. Fork
Silver Creek

TABLE 1

Land use/cover in the Highland Silver Lake Watershed, 1982, by acres and percent.

Land Use/ Cover	Highland Silver Watershed Acres	(ha)	%
Cropland	25,205	(10200.5)	82.3
Past/Hayland	1,662	(672.6)	5.4
Woodlands	1,250	(505.9)	4.1
Urban	210	(85.0)	0.7
Feedlots	116	(46.9)	0.3
Interstate Highway	49	(19.8)	0.2
Wildlife	327	(132.3)	1.1
Farmsteads	619	(250.5)	2.0
Residential	356	(144.1)	1.2
Gravel Pits	15	(6.1)	0.0
Water	830	(335.9)	2.7
Total	30,639	(12,399.6)	100.0

Agriculture is the predominant land use in the watershed with 82% of the land devoted to crop production (Table 1). Major crops grown in the watershed include corn - 8,570 acres (3468 ha), soybeans - 12,350 acres (4998 ha) and wheat - 4,285 acres (1734 ha). Pasture land comprises an estimated 5% of the watershed. The principal crop rotations are: corn/soybeans; corn/soybeans/wheat with double crop soybeans; soybeans/wheat/with double crop soybeans; corn/soybean/wheat/meadow and corn/corn/soybeans/wheat and 4 years of meadow. About 4% of the watershed is in woodland. Highland Silver Lake and other small water bodies cover about 3% of the watershed. The Village of Grantfork, the only urban area in the watershed comprises about 0.7% of the total acreage.

INVESTIGATION

Mathematical models are being used to assess nonpoint source pollution and evaluate the effects of management practices as part of the comprehensive Monitoring and Evaluation component of the Highland Silver Lake RCWP. This activity is confined to a field level modelling effort. The field level modelling effort is to determine the effectiveness of various resource management systems in reducing nonpoint source pollution at its source. The following definition of field was utilized in this study:

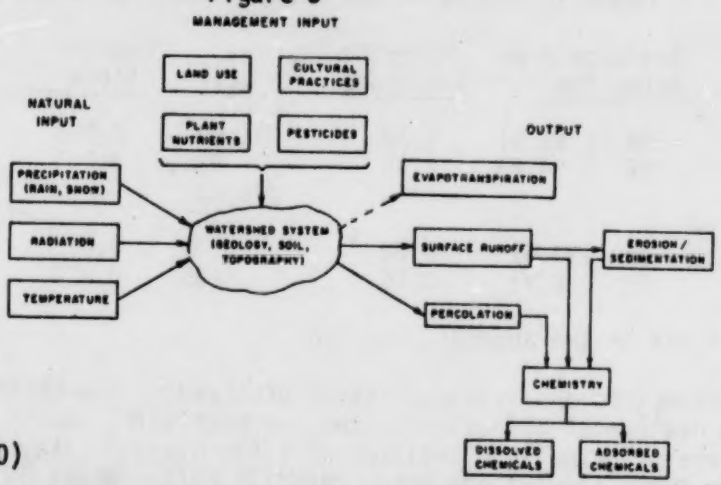
"an area with relatively homogeneous soils under a single management practice that is small enough that rainfall variability is minimal"; (Knisel, 1980) In actual applications, fields modeled ranged in size from 3 (1.3 ha) to 75 (30.4 ha) acres.

METHODOLOGY

This field approach utilized a mathematical model of the system under consideration to simulate the consequences of alternative control strategies. The validity of pollution control programs developed and implemented using this approach is entirely dependent upon the accuracy with which the model can predict the effectiveness of the control strategies being considered. The quality and reliability of input information utilized in the model is of equal importance. Therefore, not only a model capable of accurately simulating a wide range of alternatives is essential, adequate information concerning the system to be simulated is also essential.

CREAMS (Chemical, Runoff, and Erosion from Agricultural Management Systems), a mathematical model developed to evaluate non-point source pollution from field-sized areas (Knisel, 1980) was used in this investigation. CREAMS consists of three components (Fig. 3): hydrology, erosion/sedimentation, and chemical. Runoff generated from the hydrology component drives the erosion/sedimentation component of the model. The runoff and erosion/sedimentation components are then inputs for the chemical transport component of the model. The CREAMS 1 version of the model was utilized. Information on access to CREAMS is available from Walter Knisel, Project Coordinator USDA-ARA; Post Office Box 946; Tifton, GA 31793. The basic modules of CREAMS are:

Figure 3



(Knisel, 1980)

"Criteria for the deveopment of this model were: (1) the model must be physically based and not require calibration for each specific application, (2) the model must be simple, easily understood with as few parameters as possible and still represent the physical system relatively accurately, (3) the model must estimate runoff, percolation, erosion, and dissolved and absorbed plant nutrients and pesticides, and (4) the model must distinguish between management practices" (Knisel, 1980). The simulation outputs allow for relative comparisons of impacts between alternative management practices for the selected site. Assistance for using this model was provided by Drs. Thomas Dumper (SCS) and George Foster (ARS).

The daily rainfall hydrology option was used to generate hydrologic values required by the erosion/sediment yield and chemical components of the model. Precipitation during subfreezing temperature is considered snow that does not melt until air temperature is above freezing. Therefore, the results will not represent good absolute estimates when snowfall occurs. The assumed relationship Option (1) for describing the detailed sediment particles and organic matter was used, this includes: diameter, specific gravity and fraction in detached sediment.

The topographic information utilized in the CREAMS modelling effort was obtained from field measurements. The management information was obtained from RCWP cooperator record forms thru Cooperative Extension Service (CES). Gaps in the RCWP cooperator records were filled by local SCS and CES personnel estimates.

RESULTS AND DISCUSSION

CREAMS was used to model four sites within the Highland Silver Lake watershed, two of the sites correspond to CM&E sites (flume sites 2 and 6 figure 4). The information generated was utilized to compare the relative effectiveness of various BMS's on the selected sites. Table 2 gives general information concerning the CREAMS sites.

TABLE 2*

Characteristics of the CREAMS Modelling Sites

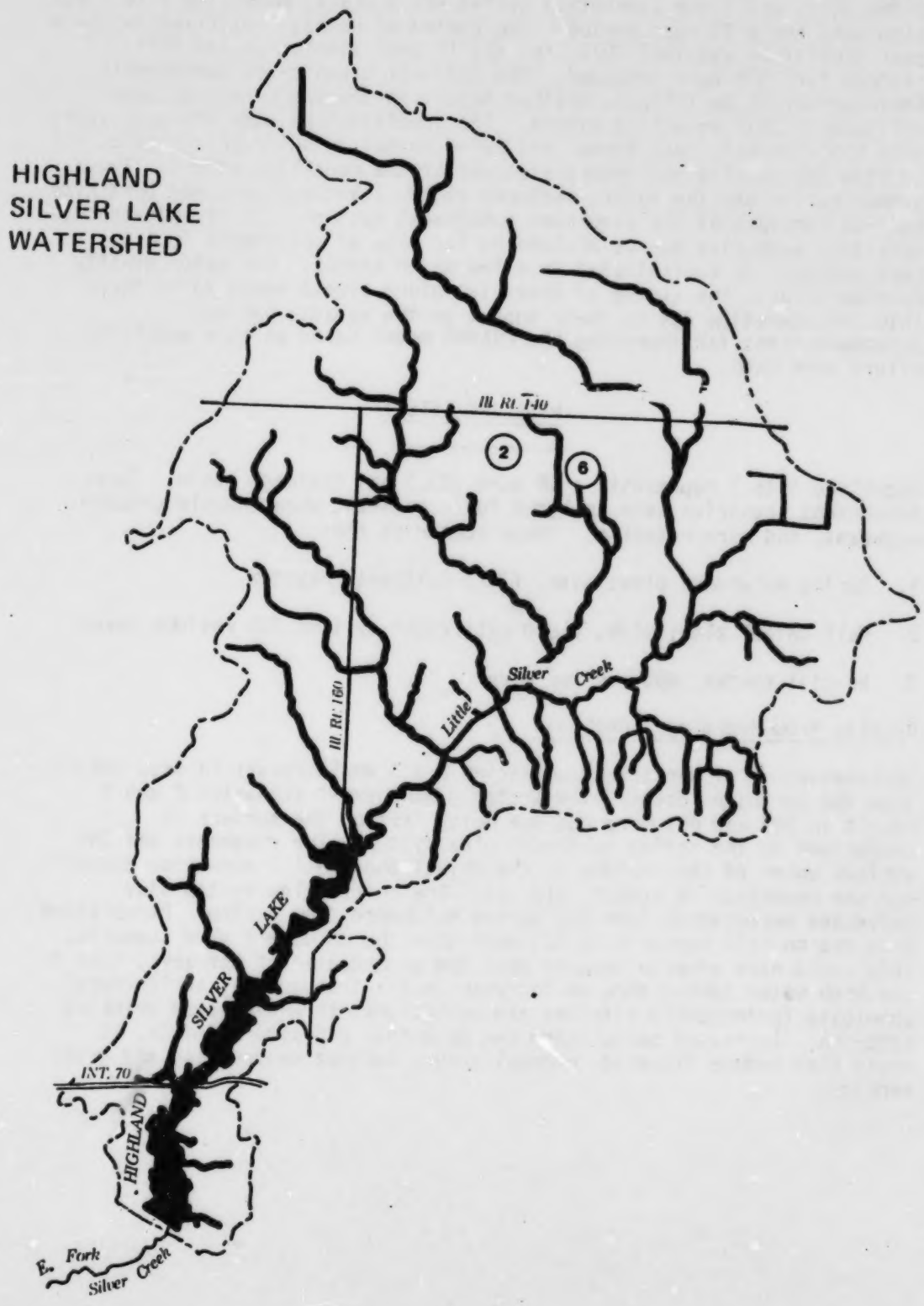
Modelling Site	Drainage Area Acres (ha)	Watershed len/width	Soil*	Channel Slope
1	58 (23.5)	1.70	916,995	0.009
2	36 (14.6)	1.49	995, 620,63, 119	0.011
3	35 (14.5)	0.88	620B	0.005
4	20 (8.1)	0.14	620B	0.027

* Soils listed in the appendix section.

The soil parameters and characteristics utilized in the CREAMS model are a weighted average of the soils listed for each site. Soils within the watershed are principally classified as silty-clays or clay. Crop yields utilized in these simulations are: corn 125 bu/ac, wheat 55 bu/ac (except modelling site 2; 60 bu/ac) and soybeans 50 bu/ac unless otherwises stated. Examination of hydrologic, erosion and nutrient outputs from varying crop yields indicated that CREAMS was not sensitive to crop yield values (Modelling Site 4).

Modelling Sites 1 and 2 correspond to water quality monitoring sites 6 and 2, respectively. (Fig. 4) Modelling Site 3 is supposed to represent non-monitored areas of the watershed that are suspected of significantly impacting water quality. Modelling Site 4 represents a non-monitored critical area of the watershed.

Figure 4


HIGHLAND
SILVER LAKE
WATERSHED
Ill. Rt. 140
2
6
Ill. Rt. 160
Little Silver Creek
LAKE
SILVER
INT. 70
HIGHLAND
E. Fork
Silver Creek

Results are summarized for the entire simulation period. For Modelling Sites 1, 2, and 3 the simulation period was 9 years, Modelling Site 4 was simulated for a 10 year period. The period of rainfall utilized in the 9 year simulation was 1967-1975, for the 10 year simulation rainfall records for 1976 were included. The National Oceanic and Atmospheric Administration, Be Illinois Weather Reporting Station's records were utilized in this modelling effort. The precipitation data includes years with above normal, near normal and below normal annual rainfall so as not to bias the results and interpretations of the modelling effort. These summaries include the water, sediment yield, plant nutrient and pesticide budgets for each of the simulated management systems. It is important to note that summaries may be misleading for mass of pollutants impact. Most sediment is concentrated in a few major storms. For water quality considerations, the timing of these few storm events needs to be taken into consideration due to their impact on the aquatic habitat. Recommendations for improving the CREAMS model based on this modelling effort were made.

MODELING SITE 1

Modelling Site 1 represents a 58 acre (23.5 ha) drainage basin. Three management scenarios were analyzed for a soybean, wheat-double cropped soybeans, and corn rotation. These scenarios are:

1. Spring moldboard plow; disk, field cultivator system.

2. Fall chisel plow; disk, field cultivator system; 30% residue cover.

3. No-till system; 80% residue cover.

Results from Hydrology Component

Implementation of management scenarios 2 & 3 would result in less runoff than the spring moldboard plow system. Management scenarios 2 and 3 result in 30% and 80% more residue being left on the surface in comparison to the spring moldboard plow system. The roughness and the surface cover of the residue in the chisel and no-till scenarios accounts for the reduction in runoff (Fig. 5). The chisel plow system also decreases percolation from the spring moldboard plow system. Percolation from the no-till scenario is 42% more than the moldboard plow scenario. This could have adverse impacts upon the groundwater of the area, (due to the high water table) thru an increase in the transport of agricultural chemicals (principally nitrites and pesticides) to groundwater drinking supplies. Increased percolation has potential off-site benefits, it could also reduce flooding, channel scour, habitat destruction and gross erosion.

TABLE 3

Hydrologic variables for management scenarios for Modelling Site 1. simulated for a total 9 year period, in inches (cm).

Management Scenario	Rainfall	Runoff	Percolation	Evapotranspiration
1	351.3 (892.3)	54.0 (137.2)	30.2 (76.7)	277.1 (703.8)
2	351.3 (892.3)	39.7 (100.8)	26.3 (66.8)	286.6 (728.0)
3	351.3 (892.3)	32.4 (82.3)	42.8(108.7)	276.5 (702.3)

Results from Erosion/Sediment Yield Component

An overland flow and a concentrated flow elements of the erosion/sediment yield component were utilized to represent the erosion/sediment yield relationship of this site for all three management scenarios. Table 4 displays the sediment yield by each element of this simulation. No-till was the most effective in reducing sediment yield among the simulated management scenarios.

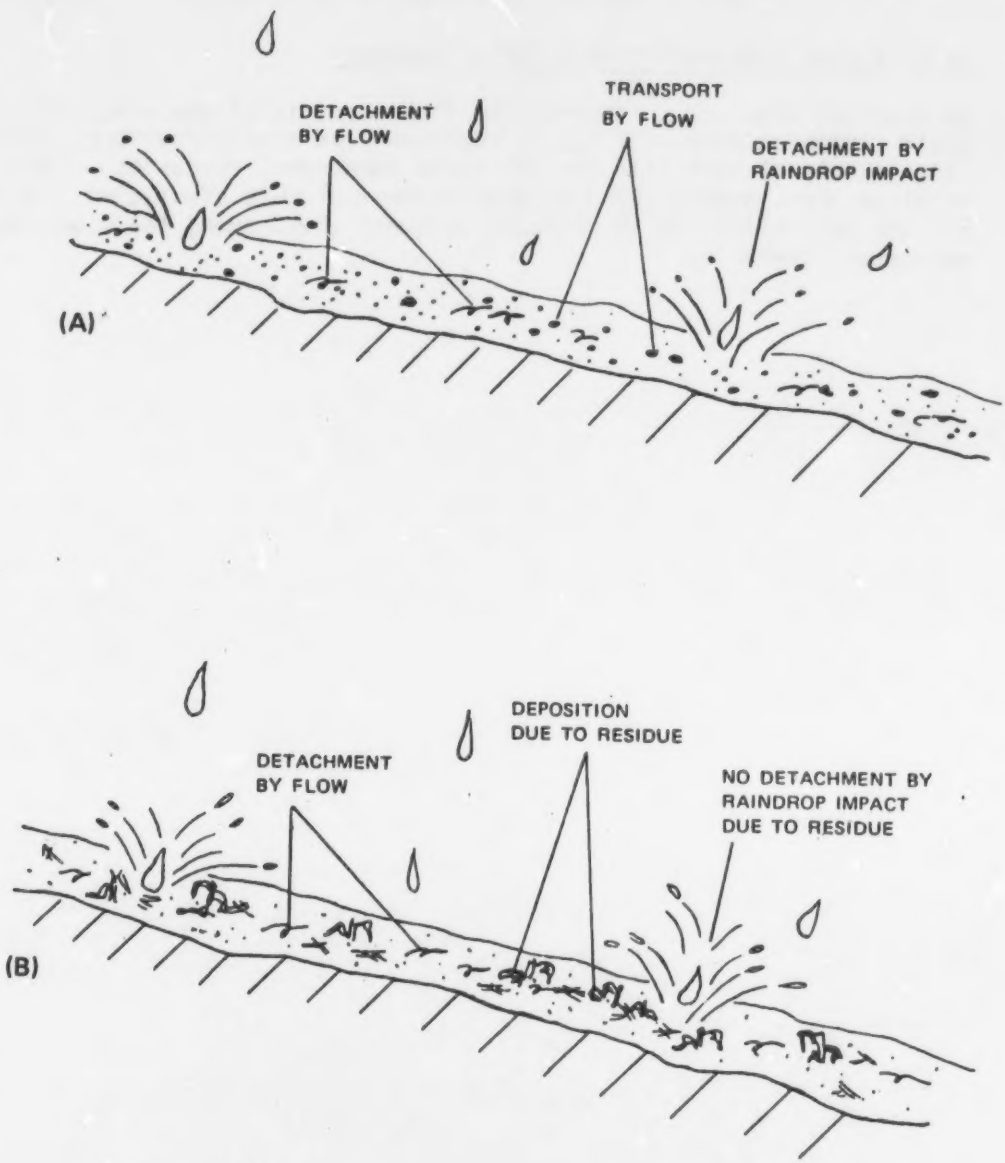


Figure 5 : Sediment Detachment and Transport on Bare (A) and Residue-covered (B) Ground During Rainfall.

TABLE 4

Sediment yield by management scenarios for Modeling Site 1, simulated for a 9 year period, in tons/acre (Kg/ha).

Management Scenarios	Overland Flow Sediment Yield	Edge of Field Sediment Yield*
1	4.13 (9251.2)	14.73 (32995.2)
2	5.37(12028.8)	17.79 (39849.6)
3	0.44 (985.6)	0.44 (985.6)

*Includes concentrated flow sediment yield

The difference between the overland flow sediment yield and the edge of field sediment yield is the quantity associated with concentrated flow erosion. Concentrated flow erosion under management scenarios 1 and 2, is contributing a significant portion of the total sediment yield leaving the site. This agrees with results of other studies, that concentrated flow erosion often contributes as much to soil erosion on a particular site as the processes of rill and interill erosion combined. (Franti; 1984; Foster, 1982). The implementation of the no-till system would reduce concentrated flow erosion and total sediment yield to a negligible amount. Since sediment yield from concentrated flow is negligible under the no-till, runoff rates are not high enough to remove soil "en masse" and only selective erosion occurs. The effect of this tillage on erosion by concentrated flow is modeled by assuming tillage decreases the critical shear stress for detachment to begin. Concentrated flow erosion only occurs when the shear stress from the runoff exceeds critical shear stress. The two principles that affect the process of selective erosion are: 1) energy limitation of runoff and 2) the availability of particular soil fraction to runoff are then maximized.

Distribution of particle size shows the impact of the different erosion processes under different management scenarios on the composition of the eroded sediment (Table 5). Clay content increases dramatically in the eroded sediment from the moldboard and chisel plow systems to the no-till system. The change in composition results from a reduction in the potential power of the runoff to erode and transport sediment due to increased ground cover, and the increased trapping efficiency of the residue on overland flow resulting in deposition when implementing a no-till system compared to the moldboard and chisel plow systems.

TABLE 5

Distribution of primary particles and organic matter, for Modelling Site 1 management scenarios, simulated for a 9 year period (in percent).

Scenario	Particle Type	Parent Material	Overland Flow Material	Edge of Field Runoff Material	ER*	Pollution Index (SY** ER)
1	Clay	0.21	0.36	0.26	1.21	17.8
	Silt	0.70	0.63	0.68		
	Sand	0.09	0.01	0.06		
	Organic Matter	0.02	0.04	0.03		
2	Cl	0.21	0.28	0.24	1.12	19.9
	Si	0.70	0.69	0.70		
	Sa	0.09	0.03	0.06		
	OM	0.02	0.03	0.03		
3	Cl	0.21	0.58	0.58	2.45	1.1
	Si	0.70	0.42	0.42		
	Sa	0.09	0.00	0.00		
	OM	0.02	0.06	0.06		

* ER: Enrichment ratio of sediment
**SY: Sediment Yield from Table 4

The enrichment ratio is defined as the ratio of the total specific surface area for the sediment to that for the original soil. Particle type composition is used to compute specific area. Thus the changes in enrichment ratio reflect the changes in particle type composition. Factors affecting the enrichment ratio include soil type, erosion type, sediment transport and the characteristics of the individual storm events (Massey, 1982). In the CREAMS model, particle composition is not used to compute transport capacity and deposition of the particle types.

Particle composition is an important component for water quality purposes. The impact of selective erosion is important in water quality terms. The product of sediment yield and enrichment ratio can be considered a pollution index for the sediment in that it measures the amount and fineness of sediment. Reduction in soil delivery does not always produce visible improvements in water quality since silt and clay particles are the hardest to control and yet contributes the most to water color and turbidity problems. Pollution index indicates, no-till proposed management should have the greatest impact on reducing off-site pollutants of the 3 proposed management scenarios, in terms of sediment and its associated impacts.

Results From Nutrient Component

Results from the plant nutrient component are summarized in Table 6 by management scenario. The results for management scenarios 1 and 2 reflect differences in runoff and sediment yield for the moldboard and chisel plow systems. Runoff decreased from the moldboard to the chisel plow system, and

the total nitrogen and phosphorus carried by runoff decreased. However, more nitrogen had leached out and more denitrification occurred under the chisel system. Nutrient losses associated with sediment were higher for the chisel system than for the moldboard system, this is a result of the increase in the sediment yield and changes in particle size composition under the chisel system. The pollution index values (Table 5) corresponds closely with the changes in sediment associated nutrient losses. This is expected since the pollution index is a measure of the amount and composition of the sediment yield for a particular managment scenario. The clay-sized soil particles and organic fraction of the sediment carry the adsorbed nitrogen and phosphorus.

The decrease in nutrient losses from the chisel and moldboard plow system to the no-till system reflect differences in fertilizer operations (method of application) and runoff/sediment yield between management systems. Leaching of nitrogen increased because of an increase in percolation. In comparison between the three management scenarios total nutrient losses associated with runoff, leaching and sediment were least for the no-till system in terms of nitrogen and phosphorus and greatest for the chisel system.

TABLE 6

Summaries of plant components of three management scenarios for Modelling Site 1, simulated for a 9 year period in pounds/acre (kg/ha).

	Management Scenarios		
	1	2	3
Nitrogen			
Inputs			
Fertilizer	814.8(912.6)	814.8(912.6)	814.8(912.6)
Rainfall	79.5(89.0)	79.5(89.0)	79.5(89.0)
Mineralization	317.7(355.8)	312.7(350.2)	317.7(355.8)
Outputs			
Runoff	52.6(59.0)	33.0(37.0)	21.2(23.7)
Sediment	93.6(104.8)	111.0(124.3)	3.8(4.3)
Plant Uptake	800.8(896.9)	803.0(899.4)	775.5(868.6)
Leaching	150.6(168.7)	169.0(183.8)	224.2(251.1)
Dentrification	133.1(149.0)	137.3(153.8)	140.9(157.8)
Phosphorus			
Inputs			
Fertilizer	231.7(259.5)	231.7(259.5)	243.2(272.3)
Outputs			
Runoff	9.1(10.2)	6.5(7.3)	7.8(8.7)
Sediment	37.4(41.9)	44.5(49.8)	1.5(1.7)

Results from Pesticide Simulation

Switching from a spring moldboard plow to fall chisel plow system with 30% residue results in a reduction in all pesticide losses except for Paraquat (Table 7). The increase in Paraquat loss is a result of higher sediment yield estimated under the fall chisel system. No-till management results in higher total pesticide losses for all pesticides except Paraquat, Sencor, Treflan and Bladex. Sencor, Treflan and Bladex are not used under the no-till system.

TABLE 7

Summary of total pesticide losses in runoff by management scenario for Modelling Site 1, simulated for a 9 year period, in grams/hectare.

	1		2		3	
Pesticide	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application
SENCOR	0.26	0.03	0.09	0.01	---	---
TREFLAN	30.79	1.83	18.35	1.09	---	---
LASSO	100.06	1.49	72.82	1.08	104.99	0.78
LOROX	33.59	2.00	24.79	1.48	46.88	1.40
PARAQUAT	0.49	0.12	2.49	0.59	0.17	0.01
DUAL	1.12	0.02	0.49	0.01	9.46	0.14
BLADEX	8.57	0.17	3.30	0.07	---	---
ATRAZINE	---	---	---	---	7.78	0.23

MODELING SITE 2

Modelling Site 2 represents a 36 acre (14.6 ha) drainage basin. Four management scenarios were analyzed for a soybeans, wheat-double cropped soybeans, corn rotation. The scenarios are:

1. Spring moldboard system.
2. Fall chisel system, 30% residue with established waterway and dry dam structure.
3. No-till system, 80% residue with established waterway and dry dam structure.
4. Spring moldboard system with established waterway and dry dam structure.

Results from Hydrology Component

Runoff was substantially less for management scenarios 2 and 3 compared to the moldboard management systems (Table 8). Percolation was considerably greater under no-till management in comparison to the other management scenarios.

TABLE 8

Hydrologic variables by management scenarios for Modelling Site 2; simulated for a 9 period, in inches (cm)

Management Scenario	Rainfall	Runoff	Percolation	Evaportranspiration
1	351.3(892.3)	53.7(136.4)	20.8(52.8)	277.4(704.6)
2	351.3(892.3)	39.5(100.3)	25.8(65.5)	286.8(728.5)
3	351.3(892.3)	32.3(82.0)	42.2(107.2)	276.4(702.1)
4	351.3(892.3)	53.7(136.4)	20.8(52.8)	277.4(704.6)

Results from Erosion/Sediment Yield Component

The overland and concentrated flow elements of the erosion/sediment yield component were utilized to represent this site for management scenario 1. For management scenarios 2, 3 and 4, the impoundment element was included in the simulation to model the impact of a grade stabilization being implemented as part of the management system. Table 9 displays the sediment yield by each element of the simulation, values are cumulative.

Concentrated flow erosion is contributing about 7% of the total sediment yield when the field is spring moldboard plowed. The combination of land management activities and rainfall occurrences during the simulated period, results in a higher overland flow sediment yield for the chisel system than the spring moldboard system. A grassed waterway and grade stabilization structure eliminated concentrated flow erosion and significantly reduced sediment yield under management scenarios 2, 3 and 4. The no-till system substantially reduced overland flow erosion and sediment yield in comparison to the other management scenarios.

TABLE 9

Sediment yield by management scenarios for Modelling Site 2; simulated for a 9 year period, in tons/acre (Kg/ha)

Management Scenario	Overland Flow	Concentrated Flow*	Edge of Field
1	22.47 (50332.8)	26.33 (58979.2)	26.33 (58979.2)
2	31.30 (70112.0)	13.27 (29724.8)	9.33**(20899.2)
3	2.03 (4547.2)	2.01 (4502.4)	1.48**(3315.2)
4	22.47 (50332.8)	10.95 (24528.0)	8.31**(18614.4)

* Includes Overland flow
** Orfice structure and Impoundment Installed

The effectiveness of the grassed waterway decreased from management scenarios 2 to 4 to 3. The grassed waterway reduced sediment yield by 1% under management scenario 3, whereas the reduction was 58% under management scenario 2 and 51% under management scenario 4, from overland flow sediment yield to the beginning of the edge of field process. This is related to the overland flow sediment yield being significantly less for the no-till system in comparison to the different management

scenarios. The scenarios where overland flow sediment yields were high had the greatest amount of reduction due to the waterway (Table 9). The installation of the grassed waterway eliminates the erosion in the waterway, much of the reduction in sediment yield is related to deposition in the waterway as shown by the increased enrichment ratio listed in Table 10. Deposition in the waterway to the extent indicated for management scenarios 2 and 4 may cause long term maintenance problems. Implementation of the no-till system reduced the overland flow sediment yield by 97% in comparison to the chisel system.

The effectiveness of the grade stabilization structure in terms of percent of sediment yield reduction from the grassed waterway under management scenarios 2, 3 and 4 is approximately the same. Installation of the structure reduces edge of field sediment yield by inducing deposition. The grassed waterway and structure as a system reduce sediment transport by deposition. Table 10 shows the increase in enrichment due to an increase in the percentage of the clay and organic matter fractions as a result of the selective settling of the coarser particles, due to increased time available for sediment to settle out as a result of the structures. There is a significant difference in the changes in the composition of the sediment particles from the grassed waterway to the structure outflow between management scenarios 2 and 3.

TABLE 10

Distribution of primary particles and organic matter analysis for Modelling Site 2, by the 4 management scenarios simulated for a 9 year period, (in percent).

Management Scenario	Particle Type	Parent Material	Overland	Concentrated[A] Flow	Impoundment[B]	ER*	Pollution Index (SY** ER)
1	Clay	0.22	0.27	0.27	----	1.20	31.6
	Silt	0.70	0.69	0.69	----		
	Sand	0.08	0.03	0.03	----		
	Organic Matter	0.02	0.03	0.03	----		
2	Cl	0.22	0.24	0.30	0.35	1.51	14.1
	Si	0.70	0.70	0.68	0.65		
	Sa	0.08	0.06	0.02	0.00		
	OM	0.02	0.03	0.03	0.04		
3	Cl	0.22	0.44	0.44	0.55	2.24	3.3
	Si	0.70	0.56	0.56	0.45		
	Sa	0.08	0.00	0.00	0.00		
	OM	0.02	0.05	0.05	0.06		
4	Cl	0.22	0.27	0.33	0.38	1.60	13.3
	Si	0.70	0.70	0.66	0.62		
	Sa	0.09	0.03	0.01	0.01		
	OM	0.02	0.03	0.03	.04		

* ER: Enrichment Ratio of Sediment
**SY: Sediment Yield from Table 9
A: edge of waterway or concentrated flow
B: leaving impoundment

Examination of the particle size composition of overland flow, concentrated flow and sediment yield in comparison to parent material content show that eroded material differed from surface soil (Table 10). The change in composition is more pronounced in the reduced tillage systems than with the moldboard plow system. The changes in enrichment ratio reflect the changes in the clay content between management scenarios.

The percentage of clay in the eroded sediment increased by 20% under the moldboard plow system and by 150% under the no-till system from the parent material. By volume the no-till system yielded the least amount of clay. According to the pollution index; spring moldboard management system has the least impact and no-till management has the greatest impact on reducing off-site pollutants. The installation of a grassed waterway and structure reduced the pollution index by almost 60%; whereas sediment yield is reduced by 70%; so a proportionate amount of clay was not reduced.

Results from the Nutrient Component

Results from the plant nutrient component are summarized in Table 11 by management scenario. Surface losses of nitrogen and phosphorus largely reflect runoff and sediment losses (Tables 8 & 9). Leaching loss among the scenarios reflect changes in percolation.

The principal differences between the chisel and no-till systems are the amount of residue left on the surface and the degree to which the soil surface is disturbed by the tillage operation. Fertilizer application was the same for both reduced tillage operations. The differences in nutrient losses between the two systems reflect the impacts of the increased residue cover and the lower soil disturbance of the no-till operation in comparison to the chisel tillage system. The major impacts of the increase in residue are: reduced surface runoff and a decrease in the amount of sediment available for detachment and transport. Nitrate leaching is greater under the no-till system because of the increase in percolation.

TABLE 11

Summaries of nutrient components of the 4 management scenarios for Modelling Site 2, simulated for a 9-Year period, in pounds/acre (Kg/ha).

	Management Scenarios			
	1	2	3	4
Nitrogen				
Inputs				
Fertilizer	759.9(851.1)	759.9(851.1)	759.8(851.1)	759.9(851.1)
Rainfall	79.5(89.0)	79.5(89.0)	79.5(89.0)	79.5(89.0)
Mineralization	316.5(354.5)	258.6(289.6)	324.3(363.2)	316.5(354.5)
Outputs				
Runoff	55.2(61.8)	26.6(29.8)	20.9(23.4)	55.2(61.8)
Sediment	167.9(188.0)	79.3(88.8)	15.4(17.2)	71.4(80.0)
Plant Uptake	811.3(908.6)	611.3(684.6)	764.5(856.2)	811.3(908.6)
Leaching	135.5(151.8)	82.9(92.8)	184.1(206.2)	135.5(151.8)
Dentrification	124.7(139.7)	76.6(85.8)	110.5(123.8)	124.7(139.6)
Phosphorus				
Inputs				
Fertilizer	256.1(286.8)	256.1(286.8)	256.1(286.8)	256.1(286.8)
Outputs				
Runoff	8.9(10.0)	6.3(7.1)	6.3(7.1)	8.9(10.0)
Sediment	67.2(75.3)	31.7(35.5)	6.1(6.8)	28.5(31.9)

Results of the Pesticide Simulation

The establishment of a grassed waterway and an impoundment under a spring moldboard management system results in a reduction in Paraquat, Atrazine, Bladex, Treflan and Lorsban losses. Comparing the impact of switching from a spring moldboard to a fall chisel system (where a grassed waterway and impoundment have been installed) indicates pesticide losses are less under the fall chisel system. Quantity of clay-sized soil particles (Table 10) and runoff (Table 8) are less for the chisel system than the spring moldboard plow system, this impacts the quantities of strongly and intermediately adsorbed pesticides transported from the site. Since clay quantity is reduced, strongly adsorbed pesticides losses would be less for the chisel system. The magnitude of reduction is dependent upon the control of the clay fraction of sediment (Burns, 1973). Intermediately adsorbed pesticides are reduced approximately proportional to decreases in runoff volume (Hall, 1972 and Kearny, 1972). No-till management results in less pesticide loss in comparison to spring moldboard with or without a grassed waterway and structure except for Lorox. Fall chisel system in comparison to no-till management results in less pesticide loss for Lasso, Lorox, Atrazine, and Bladex.

TABLE 12

Summary of total pesticide losses in runoff by management scenario for Modelling Site 2, simulated for a 9 year period, in grams/hectare.

	1		2		3		4	
Pesticide	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application
SENCOR	0.24	0.03	0.04	0.00	--	---	0.24	0.03
TREFLAN	63.42	1.89	19.76	0.59	---	---	53.29	1.59
LASSO	100.16	1.49	9.83	0.15	90.21	0.67	100.16	1.49
LOROX	33.68	2.00	8.47	0.50	38.69	1.15	33.68	2.00
PARAQUAT	1.34	0.32	0.87	0.21	0.57	0.05	0.86	0.20
ATRAZINE	11.61	0.35	4.28	0.13	6.28	0.19	11.20	0.33
BLADEX	9.01	0.18	3.30	0.07	4.76	0.09	8.49	0.17
LORSBAN	78.76	2.34	25.06	0.75	11.17	0.33	52.57	1.56

MODELLING SITE 3

Modelling Site 3 represents a 35 acre (14.5 ha) drainage basin. Two management scenarios were analyzed for a soybean, wheat -- double cropped soybean, corn rotation. The two management scenarios are:

1. Spring moldboard plow; disk, field cultivator system.

2. Fall chisel plow; disk, field cultivator system 30% residue cover.

Results from Hydrology Component

The implementation of the fall chisel plow system on this site in comparison to the spring moldboard plow system would result in slightly less runoff and percolation and greater evapotranspiration (Table 13). The combination of land management activities and rainfall occurrences during the residue management season (November-March) result in lower than expected differences in runoff. Precipitation during January and February normally occurs as snowfall or rainfall on snow cover several times during the 10 year precipitation period used in this modelling effort; precipitation occurred as rainfall when no snowpack was present.

TABLE 13

Hydrologic variables for management scenarios for Modelling Site 3, for a 9 year period, in inches (cm).

Management Scenario	Rainfall	Runoff	Percolation	Evapotranspiration
1	351.3 (892.3)	72.1 (183.1)	10.4 (26.4)	270.2(686.3)
2	351.3 (892.3)	70.1 (178.0)	7.2 (18.3)	275.6(700.0)

Results from Erosion/Sediment Yield Component

The overland flow element of the erosion/sediment yield component was utilized to represent potential sediment yield from this site. Table 14 displays the sediment yield by simulation.

As noted earlier, the combination of land management activities and the unseasonal distribution of precipitation occurrences (rainfall instead of snow) resulted in soil loss estimates different from what could be expected or previously reported in literature (Humenik, 1982). There was an increase in overland flow sediment yield when switching from spring moldboard plow to a fall chisel plow; 30% residue cover. The absolute difference is 0.43 tons (390 kg) over the 9 year simulation period or 0.05 tons (44 kg) per year difference, which is insignificant after considering the accuracy of the predictive process and the number of assumptions that were made.

TABLE 14

Sediment yield by management scenarios for Modelling Site 3; simulated for a 9 year period, in tons/acre (kg/ha).

Management Practice	Overland Flow Sediment Yield
1	1.20 (2688.0)
2	1.63 (3651.2)

Examination of the predicted particle size of the overland flow sediment yield in comparison to parent material content shows that the eroded material differed from surface soil (Table 15). The clay content of the eroded material under either scenario is considerably higher than the parent material. By volume, sediment yield under either scenario would not be considered excessive in terms of soil productivity, but in water quality terms the composition of the eroded material can lead to impaired use of the affected water resource. The clay, silt and organic matter of the eroded material can contribute to water color, nutrient and turbidity problems.

There is no sand in the eroded material under either management scenario. The lack of sand in the eroded material is a result of the lack of energy available for overland flow transport which results from the site being relatively flat.

TABLE 15

Distribution of primary particles and organic matter, for Modelling Site 3 by management scenarios, simulated for a 9-year period (in percent).

Management Practice	Particle Type	Parent Material	Overland Flow Material	ER*	Pollution Index (ER X SY**)
1	Clay	0.18	0.48	2.27	2.7
	Silt	0.69	0.52		
	Sand	0.13	0.00		
	Organic Matter	0.01	0.04		
2	Cl	0.18	0.37	1.80	2.9
	Si	0.69	0.63		
	Sa	0.13	0.00		
	OM	0.01	0.03		

* ER: Enrichment ratio of sediment
**SY: Sediment Yield

Table 15 shows the enrichment ratio under the two management scenarios. The decrease in enrichment ratio from the spring moldboard plow system to the fall chisel plow system is a result of the decrease in clay content in the eroded material. The decrease in clay content is attributable to the lack of available source areas for detachment under the fall chisel plow system, due to the residue cover. The pollution index indicates both management system have similar potential off-site impacts.

Results from the Nutrient Component

Results from the plant nutrient component are summarized in Table 16 by managment scenario. The fertilizer application system (amount, method and timing)was the same for both management scenarios.

The chisel plow system had greater surface (runoff & sediment) loss of nitrogen and phosphorus than the spring moldboard plow systems, total nutrient loss (surface & leaching) is approximately the same under both management scenarios on an annual basis the differences are minimal. This difference is attributable to the interaction of land management activities and unseasonal rainfall occurrences instead of snow and the effect upon nutrient related processes.

TABLE 16

Summaries of nutrient components of the management scenarios for Modelling Site 3, simulated for a 9 year period, in pounds/acre (kg/ha).

	Management Scenarios	
	1	2
Nitrogen		
Inputs		
Fertilizer	814.8(912.6)	814.8(912.6)
Rainfall	79.5(89.0)	79.5(89.0)
Mineralization	311.0(348.3)	311.0(348.3)
Outputs		
Runoff	95.2(106.6)	107.9(120.8)
Sediment	11.4(12.8)	14.4(16.1)
Plant Uptake	839.9(940.7)	875.5(980.6)
Leaching	86.9(97.3)	70.8(79.3)
Dentrification	97.9(109.6)	51.9(58.1)
Phosphorus		
Inputs		
Fertilizer	232.2(260.1)	232.2(260.1)
Outputs		
Runoff	12.5(14.0)	12.1(13.6)
Sediment	4.5(5.0)	5.8(6.5)

Results from the Pesticide Simulation

Paraquat, a strongly adsorbed pesticide, attaches readily to clay thus losses reflect the effects of management systems on the erosion process. The remaining pesticides losses were either the same for both management systems or slightly less under the fall chisel system.

Table 17

Summary of total pesticide losses in runoff by management scenario for Modelling Site 3, simulated for a 9 year period, in grams/hectare.

	1		2	
Pesticide	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application
SENCOR	0.67	0.08	0.55	0.07
TREFLAN	35.01	2.08	29.03	1.73
LASSO	136.21	2.03	136.67	2.03
LOROX	46.04	2.74	45.82	2.73
PARAQUAT	0.19	0.05	0.26	0.06
DUAL	1.66	0.03	1.30	0.03
BLADEX	15.26	0.30	12.10	0.24

MODELLING SITE 4

Modelling Site 4 represents a 20-acre (8.09 ha) drainage basin. Three management systems were analyzed for a soybean, wheat -- double cropped soybean rotation. The three management scenarios are:

1) Spring chisel plow; disk, field cultivator system less; than 20% residue cover.

2) Spring chisel plow; disk, field cultivator system less than 20% residue cover, contoured.

3) No-till, 80% residue cover.

Management scenario 2 was run twice with the only change being the crop yield. Soybean yield was assumed to be 50 bushels per acre for managment scenarios 1, 3 and the first run of 2. In the second simulation of management scenario 2, the yield was reduced by 30%.

Results from Hydrology Component

TABLE 18

Hydrologic variables for management scenarios for Modelling Site 4; simulated for 10 year period in inches (Kg/ha).

Management Scenario	Rainfall	Runoff	Percolation	Evapotranspiration
1	379.2(963.2)	58.9(149.6)	15.6(39.6)	307.5(781.0)
2	379.2(963.2)	44.0(111.8)	22.8(57.9)	314.9(799.8)
3	379.2(963.2)	44.0(111.8)	22.8(57.9)	314.9(799.8)

Percolation was greater for management scenarios 2 and 3 in comparison to management scenario 1. Spring chisel plow contoured and the no-till management scenarios had the same water budgets.

Results from Erosion/Sediment Yield Component

The overland flow element of the erosion/sediment yield component was utilized to represent potential erosion on this site. Table 19 displays the sediment yield for each simulation. The sediment yield estimate is the same as the overland flow sediment yield estimate.

Spring chisel plow system on the contour reduces sediment yield by 55% in comparison to first spring chisel plow system. Under the no-till management scenario overland flow sediment yield was reduced by 89 and 75 percent in comparison to spring chisel plow and spring chisel plow on the contour, respectively. The 75% reduction in sediment yield from the spring chisel plow system on the contour to the no-till system is principally the result of the increase residue on the surface.

TABLE 19

Sediment yield by management scenarios for Modelling Site 4; simulated for a 10 year period in tons/acre (Kg/ha).

Management Scenario	Overland Flow Sediment Yield
1	40.67 (91100.8)
2	18.27 (40924.8)
3	4.57 (10236.8)

TABLE 20

Distribution of primary particles and organic matter; analysis for Modelling Site 4's management scenarios simulated for a 10 year period (percent)

Management Scenario	Particle Type	Parent Material	Overland Flow Material	ER*	Pollution Index ER X(SY**)
1	Clay	0.18	0.19	1.05	42.7
	Silt	0.69	0.70		
	Sand	0.13	0.11		
	Organic Matter	0.01	0.01		
2	Clay	0.18	0.19	1.05	19.2
	Silt	0.69	0.70		
	Sand	0.13	0.11		
	Organic Matter	0.01	0.01		
3	Clay	0.18	0.27	1.37	6.3
	Silt	0.69	0.70		
	Sand	0.13	0.03		
	Organic Matter	0.01	0.02		

* ER: Enrichment ratio of sediment
**SY: Sediment Yield from Table 18

Examination of the particle size of overland flow in comparison to parent material shows that the eroded material's composition differed from the surface soil. The change in composition is more pronounced in the no-till system than the spring moldboard plow systems. The changes in enrichment ratio reflect the changes in the clay content between management scenarios. Contouring reduced the pollution index by 55% over the existing spring moldboard system with similar residue levels. Implementation of a no-till system reduces the pollution index by 85% over the existing system and 67% over the contoured system.

Results from the Nutrient Component

Results from the plant nutrient component are summarized in Table 21 by management scenario. Surface losses of nitrogen and phosphorus largely reflect runoff and sediment losses (Tables 18 and 19). Leaching losses among the scenarios reflect changes in percolation (Table 18).

The principal differences between the no-till and the spring moldboard plow system on the contour reflect the differences in overland flow sediment yield between the scenarios. Runoff was the same for both scenarios. 44.0 inches (111.8 cm), so sediment transport potential is assumed equivalent. The principal difference is the decreased available source area for sediment detachment under the no-till system in comparison to the spring moldboard plow on the contour system.

The outputs of nitrogen exceed inputs in all three scenarios. This is a result of using soybean yields that were reported for an exceptionally good year instead of the norm which is 30% lower.

TABLE 21

Summaries of nutrient components of the management scenarios for Modelling Site 4, simulated for a 10 year period in pounds/acre(kg/ha)

	Management Scenarios			
Nitrogen	1	2A	2B	3
Inputs				
Fertilizer	430.0 (481.6)	430.0 (481.6)	(481.6)	430.0(481.6)
Rainfall	85.8 (96.1)	85.8 (96.1)	(96.1)	85.8(96.1)
Mineralization	329.4 (368.9)	329.4 (368.9)	(368.9)	329.4(368.9)
Outputs				
Runoff	45.1 (50.5)	27.3 (30.6)	(30.6)	27.3(30.6)
Sediment	247.9 (277.6)	128.3 (143.7)	(143.7)	40.6(45.5)
Plant Uptake	600.9 (672.0)	604.4 (676.9)	(676.9)	604.4(676.9)
Leaching	83.8 (93.9)	105.0 (117.6)	(117.6)	105.0(117.6)
Dentrification				
Phosphorus				
Inputs				
Fertilizer	204.9 (229.5)	204.9 (229.5)	(229.5)	204.9(229.5)
Outputs				
Runoff	9.8 (11.0)	7.2 (8.1)	(8.1)	7.2(8.1)
Sediment	99.2 (111.1)	51.3 (57.5)	(57.5)	16.2(18.1)

2A. Soybean yield 50 bu/ac
2B. Soybean yield 35 bu/ac

Results from the Pesticide Simulation

Comparing total pesticide loss for management scenarios 1 and 2 indicate contouring substantially reduces the amount of pesticide loss. No-till management results in higher loss of Lasso, Lorox and Paraquat in comparison to spring chisel system on the contour. Comparing spring chisel and no-till management indicates that no-till results in greater losses of Lasso and Lorox and that under spring chisel management Paraquat losses are slightly greater than under no-till.

TABLE 22

Summary of total pesticide losses in runoff by management practice for Modelling Site 4, simulated for a ten year period in grams/hectare.

	1		2		3	
Pesticide	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application	Total Mass G/ha	% of Application
SENCOR	0.56	0.04	0.21	0.01	---	---
TREFLAN	40.89	1.46	26.76	0.96	---	---
LASSO	53.37	0.48	32.96	0.29	140.35	0.63
LOROX	38.20	1.36	25.28	0.90	84.67	1.51
PARAQUAT	2.58	0.37	1.41	0.20	2.35	0.17

Conclusions

1. Longer simulation periods (approximately 20 years) are required to evaluate alternative management practices on individual sites because of the extreme variability in precipitation between and within years. This time frame corresponds closely to the 22-year station rainfall records used in computing rainfall values for the USLE.

2. The analysis highlighted the problems associated with determining the relative quantity and impact of concentrated flow erosion. Since concentrated flow is an identified type of soil erosion a procedure must be developed to estimate its magnitude on non-modelled sites. In Illinois a study is underway to develop an equation for quantifying (MEGARILL) concentrated flow erosion.

3. The analysis indicated that no-till is extremely effective in reducing sediment yield in comparison to conventional and reduced tillage systems.

4. Contouring was effective in reducing overland flow sediment yield, nutrient and pesticide loss.

5. A pollution index based on the sediment yield and enrichment ratio values gives an indication of potential off-site impacts of soil erosion.

6. The pollution index can serve as a relative measure of nutrient losses associated with sediment transport for different simulated management scenarios.

7. Sediment carried in runoff from fields managed under multiple stage crop-rotations will vary by crop stage of rotation. RMS's should be designed to minimize the effect of the maximum sediment production stage of the rotation.

8. Computer simulations documented selective erosion was occurring. Since previous studies (Davenport, 1983 & Davenport, 1984) showed that finer material (clay, organic matter) remained in suspension due to the sodium influence; practices which control the soil eroison detachment and transport mechanisms for the finer particles should be recommended to land owner/operators within the Highland Silver Lake Watershed.

9. Computer simulations indicated effectiveness of cultural practices varies by season, due to crop canopies and residue cover being seasonally dependent. These computer simulations showed that fall tillage with 30% residue can produce more sediment yield than spring moldboard plowing under specific climatic conditions.

10. Local conservationist must know the problem they are trying to solve before using this model. Computer simulations indicate that specific management systems do not necessarily minimize sediment, plant nutrients and pesticides for each site, thus the management system recommended should be the one that minimizes the identified problem for that site.

11. CREAMS provided an effective way to evaluate a number of alternative management systems for each site.

CREAMS MODEL RECOMMENDATIONS

1) Develop an English-Metric System: Conversion Option for outputs, this would allow the user to specify the system the ouputs are produced in.

2) For the total summary component of nutrient and pesticide submodels, develop a procedure to list out fertilizer and pesticide applications by date. Include in the listing; rate of application and surface fraction. For pesticides, also include incorporation efficiency.

3) Develop subroutines that preprogram pesticide information within the model that presently users have to determine off of charts and tables. This will allow updating of the information in an efficient and effective manner, and decrease user input time.

4) List potential soil loss, whenever calculated sediment yield is given for an area. This will allow the calculation of sediment delivery ratios by storm and on annual basis.

5) To enhance the use of the model in terms of water quality activities, information should be reported in water quality terms, i.e. concentrations. A probability density function for the total simulation period based upon average storm event concentrations would allow for a water quality comparison between management systems.

6) Productivity - crop yield relationships should be incorporated into all three components of the model, not just the chemical component.

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APPENDIX SECTION

Appendix A

Location, physical description and morphometry of Highland Silver Lake, Madison County, Illinois

Lake

Latitude	38° 46' 07"
Longitude	89° 41' 55"
Basin	Kaskaskia
Segment	A03
Maximum length	4 1/2 miles (7.24 Km)
Surface acres	550.0 acres (222.58 ha)
Maximum depth	28.0 feet (8.5 m)
Mean depth	10.0 feet (8.0 m)
Length of shoreline	12.00 miles (19.3 Km)
Bottom slope	0.40
Storage volume	5,500 acre feet (678 1500 m^3)
Retention time	0.52 Year
Annual capacity loss	0.69 percent
Ratio of drainage area and lake capacity	5.5

Watershed

Major tributary	Little Silver Creek
Drainage area	30,638 Acres (12,399.2 ha)
Area excluding lake	30,040 Acres12,157.2 ha)

Davenport & Kelly, 1983

Appendix B

Number and soil type

Number	Soil Type	K	T	HYD Soil Group
916	Darmstadt -- Oconee Sil Complex	.41	3	D
995	Herrick -- Piasa Sil Complex	.34	4	C
620	Darmstadt Sil	.43	3	D
119	Elco Sil	.37	5	B
68	Sable	.28	5	D

Appendix C

Glossary

Overland Flow Sediment Yield: Sediment yield generated from the overland flow component of the erosion/sedimentation submodel. "The overland flow subprogram computes interrill-rill (sheet-rill) erosion and sediment transport by overland flow." (Knisel, 1980: p. 194)

Concentrated (Channel) Flow Sediment Yield: "The channel subprogram represents detachment and sediment transport in terrace channels; waterways; and small intermittent streams. Flow concentrations also include areas through the middle of a field where overland flow concentrations alos include areas through the middle of a field where overland flow concentrates due to natural topography (Knisel, 1980: p. 195).

Impoundment: "The pond subprogram estimates deposition of sediment in impoundment terraces having controlled pipe outlets. Deposition in shallow natural impoundments caused by a ridge around a field, heavy vegetation at the outlet to the field, or a pipe culvert is analyzed with the channel element and a backwater curve" (Knisel, 1980: p. 196).

Trade Name	Common Name
SENCOR:	Metribruzin
TREFLAN:	Trifluralin
LASSO:	Alachlor
LOROX:	Linuron
PARAQUAT:	Ortho Paraquat
DUAL:	Metolachlor
BLADEX:	Cyanazine
ATRAZINE:	Atrazine
LORSBAN:	Chlorpyrifos

TED:cb/520d,spl-51